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Growth Poles and Multipolarity

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Abstract

This paper develops an empirical measure of growth poles and uses it to examine the phenomenon of multipolarity. The authors formally define several alternative measures, provide theoretical justifications for these measures, and compute polarity values for nation states in the global economy. The calculations suggest that China, Western Europe, and the United States have been important growth poles over the broad course of world history, and in modern economic history the United States, Japan, Germany, and China have had prominent periods of growth polarity. The paper goes on to analyze the economic and institutional determinants, both at the proximate and fundamental level, that underlie this measure of polarity, as well as compute measures of dispersion in growth polarity shares for the major growth poles.

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1 Introduction

The post-financial crisis global environment has been marked by a sharp rise in international economic tensions. Heightened protectionist sentiment and accusations of exchange rate manipulation have given rise to talk of trade collapse and currency wars. These tensions have manifested themselves in international fora, such as the stalled Doha Round and stalemate at the recent Seoul G20 meetings. While frictions in the global policy dialog are not new, the increased assertiveness expressed by the large emerging market powers suggests that deeper forces are afoot. What are the changes taking place in the global landscape that may be driving this phenomenon?

We contend in this paper that a large part of the explanation lies in the increasing multipolarity in international economic relations. The increasingly important role of the developing world in driving global economic growth translates into real economic power. While the developed economies of today dominated global economic production, consumption, transactions, and institutions throughout much of the 20th century, they are increasingly ceding economic prominence to the emerging world, with the share of the Global North shrinking from about 59 to 44 percent of world GDP between 1973 and 2008. International economic flows, such as trade and investment, increasingly originate from, and are destined for, countries in the Global South. This paper seeks to make sense of these shifts in global economic power, from the perspective of economic growth and influence.

Of course, such shifts in global economic polarity are not new. Throughout the trajectory of modern economic history, each phase of global growth has been driven by a small set of countries, often called global "growth poles." Between the Tang and Ming dynasties (600-1600), China was a dominant force in the global economy, accounting for a quarter of its output and as much as a third of its growth. The Renaissance saw the beginning of the rise in the economies of Western Europe—beginning first with Italy, Portugal, and Spain; then, with the advent of the Industrial Revolution, France, Great Britain, and Belgium—accompanied by a transformation of incomes, production, and trade. Following the Second World War, global growth was led not only by the United States—especially the mutually reinforcing engines of American innovation and strong consumer demand—but by postwar Germany, Japan, and the former Soviet Union, which were also economic drivers in their own right.

In spite of the widespread use of the expression "growth poles" in the policy discourse, there has been little consensus as to accepted definitions of the term. In this paper, we undertake the task of formally defining several alternative measures of growth poles, drawing on the theoretical literature that has examined the manner by which growth in a given country can potentially influence the growth in others. We go on and compute a range of different polarity measures for nation states in the global economy, and demonstrate the relative robustness of our benchmark measure.

The term "growth pole" was originally used to describe a growth process located in economic space, and incorporated spillover considerations (Perroux 1950). However, the term quickly took on a geographic or spatial dimension, and existing explorations of growth poles have focused on vertical linkages and external economies of scale in that regard. While a better understanding of the tension between forces supporting greater agglomeration versus specialization have clear value from both the point of view of theory (Fujita, Krugman & Venables 1999) as well as policy (Bank 2009), this focus on *physical* space has meant that empirical papers in this vein take on, almost by definition, a regional tone (see, for example, Anselin (2003) or Fingleton (2001)). As a consequence, the rich linkage, multiplier, and spillover effects are accorded more in terms of geographic rather than economic space.

This shortcoming in the existing empirical literature becomes amply clear in the global context, where growth spillovers often span standard geographic boundaries. India's largest trading partners, for example, do not include Pakistan nor Bangladesh, and U.S. outflows of FDI are destined for China as much as they are for Canada.[1] However, empirical growth papers that incorporate spatial elements tend to be constrained to notions of absolute geographic position (Gallup, Sachs & Mellinger 1999; Moreno & Trehan 1997; Rodrik, Subramanian & Trebbi 2004). Even studies that employ much more sophisticated techniques to the study of spatial elements—as embodied in the spatial econometrics and growth literature (see Rey & Janikas (2005) for a recent review)—similarly limit their focus to relative physical space. A clear gap remains in the profession's understanding of growth poles, as they apply at the global level.

Moreover, with the bulk of the academic literature focused on theoretical expositions, the empirical study of growth poles has also been limited to fairly narrow treatments of the topic. Many papers that consider some aspect of growth polarity are focused mainly on one channel—that of technological spillovers (Coe & Helpman 1995)—and considerations of alternative transmission channels have resorted to the somewhat unsatisfactory approach of using physical space as a proxy for all other bilateral ties (Keller 2002). Furthermore, the scope of most studies are intra-country or regional in nature. To the extent that the literature has considered cross-country studies of growth externalities, these tend to be focused more on negative, rather than positive, spillover effects (Ades & Chua 1997; Murdoch & Sandler 2002).

The fields of political science and international relations have long been interested in the study of the distribution of power. However, existing papers discussing the issue of multipolarity typically employ concentration measures premised on some vaguely-defined notion of power, such as economic or political power, and more often than not these are simply attributed to size (Mansfield 1993; Ray & Singer 1973). In addition, measures of this form tend to capture contemporaneous distributions of power, rather than potential paths of influence. Finally, the treatment of economic polarity in this context is somewhat primitive, ignoring how knowledge transfer, agglomeration economies, gains from exchange, and spillover externalities that allow the pole to potentially influence growth elsewhere.

[1] Nor should this be too surprising. The gravity model (of trade) suggests that bilateral trade volumes are determined primarily by *both* economic size and physical distance, and neatly captures both of these dimensions in cross-country economic relations.

Other classical power indices, such as the Penrose (1946)-Banzhaf (1965) index or the Shapley & Shubik (1954) index, are reasonable measures of influence, especially as it pertains to bargaining power. However, in the context of international economic relations, the biggest drawback is that voting indices require a voting mechanism to be operational and/or relevant, which may not be the case in many forms of international interactions. Furthermore, like concentration indices, voting indices likewise do not capture any growth or growth spillover effects. Measures of multipolarity would clearly benefit from a more well-defined measure of power shares.[2]

Our calculations suggest that China, Western Europe, and the United States have been important growth poles over the broad course of world history, and in modern economic history the United States, Japan, Germany, and China have had prominent periods of growth polarity. In the most recent 2004–08 period, China, India, and Russia appear poised to be growth poles among the emerging economies, with Russia, Saudi Arabia, and South Korea possessing the potential as well.

The paper goes on to the analyze the determinants of such growth poles, taking into careful account the possible endogeneity and simultaneity issues that may be of concern. We find that among proximate determinants, per capita income and the dependency ratio are especially important, while institutional quality and economic integration appear to be more central fundamental determinants.

The paper is organized as follows. The next section (Section 2) provides the theoretical background for the various transmission channels considered in the construction of the empirical measure (Section 3). This section also reports estimates of growth poles using the available international data, along with various robustness checks for the measure. Section 4 considers the proximate and fundamental factors that underlie growth polarity, and Section 5 applies the measure to consider the phenomenon of multipolarity. A final section concludes with the way forward.

2 From poles to periphery: channels by which poles drive global growth

There is no absolute consensus regarding which fundamental channels transmit growth from one economy to another. However, a handful of channels are strongly suggested by at least some theory and empirical evidence. There are strong theoretical underpinnings for the idea that technological progress is a key driver of long-run growth (Romer 1990; Solow 1956). This suggests that we begin by considering channels by which technologies diffuse from one economy

[2] A recent literature has also emphasized power exerted through indirect or sociocultural influence, or "soft" power (Nye 2004). However, soft power is (almost by definition) difficult to quantify. Although proxies may be available—such as the global spread of a country's language, education institutions, or national values and philosophy—measures that have emerged from the literature remain largely subjective, limited in scope, and are not systematically produced.

to others.[3] These include flows of knowledge through trade, capital flows, or migration, as well as more direct flows of technology embodied in physical and human capital.

In addition to diffusion of technology itself, we might also consider the diffusion of any underlying factor that promotes technological progress, especially the transfer of institutions that shape incentives to develop new technologies or to adopt existing technologies. Although, intuitively, the transfer of economic institutions may be quite important, institutional change is typically difficult to measure, and slow; attempting to capture international transmission of most kinds of institutional change would present even further difficulties. However, some institutional transfer may be captured simply by the data on a potential pole's growth rate and the size of its economy. It is plausible that when reform of economic institutions promotes growth, people in other countries take notice and demand similar reforms of their own governments. Moreover, the larger the economy in which the reforms and growth took place, and the more rapid the growth, the more conscious people in other countries will be of these events, *ceteris paribus*. Trade, foreign direct investment (FDI), and international migration may also facilitate some transfer of economic institutions, and these should be considered in evaluating potential poles in any case, since they may be important channels by which technological knowledge is transferred between economies.

Trade may propagate growth from poles to periphery economies, at least in part as a channel of technological diffusion. Grossman & Helpman (1991b) provide a theoretical framework in which knowledge accumulation by domestic industrial agents depends on the extent of contact with their foreign counterparts, and thus on their levels of commercial exchange with foreign firms, so that the evolution of comparative advantage and technological progress are interlinked and jointly determined. Trade in intermediate goods, in particular, may also function as a channel of technology diffusion and spillover in a second, weaker way, distinct from knowledge spillovers: intermediate goods embody technologies, so importation of intermediate goods can reduce costs of product development and production of new products (Eaton & Kortum 2002; Grossman & Helpman 1991a; Rivera-Batiz & Romer 1991).

The broad implication that trade and FDI may be important channels of technology diffusion is supported by a small body of empirical research. For example, Hallward-Driemeier, Iarossi & Sokoloff (2002) find that, in East Asia, firm openness is associated with subsequent advantages in firm-level productivity. However, this result is only strong for less developed countries in the region, such as Indonesia and the Philippines. There is greater empirical support for importation as a significant channel of technology diffusion than exportation; however, a pole may drive growth in a periphery economy simply by absorbing its exports and driving expansion of exporting industries. Exportation is also associated with intraindustry reallocation of production from low-productivity to high-productivity firms (Melitz 2003), and in some industries, market size effects stemming from increasing returns to scale (Krugman 1979). Thus, it is plausible that growth may be driven by bidirectional trade: both importing from a pole,

[3] For a survey of this literature, see Keller (2004).

and exporting to a pole.

Capital flows, particularly FDI, may also be an important channel of technological diffusion. Theoretically, multinational parents may transfer technological knowledge to their subsidiaries (Ethier 1986; Markusen 2004). Knowledge may spill over from subsidiaries to other firms in the host country through labor turnover (Fosfuri, Motta & Rønde 2001). Multinationals can also provide subsidiaries with technology embodied in intermediate goods and services (Rodríguez-Clare 1996). However, there is only weak empirical evidence that FDI is, more broadly, an important channel of technological diffusion, and the evidence that FDI facilitates large intraindustry spillovers is also decidedly mixed. Large intraindustry spillovers are found primarily in some case studies of high-technology FDI projects (for example in the case of microchip-maker Intel in Costa Rica, as studied by Larraín, López-Calva & Rodríguez-Clare (2001)) and studies of samples of firms drawn from relatively high-technology sectors (as in the case of Keller & Yeaple (2009) for U.S. manufacturing). Firm-level studies using broader samples have typically found evidence of only small intraindustry spillovers (Griffith, Redding & Simpson 2004; Haskel, Pereira & Slaughter 2007). There is also some evidence of vertical spillovers, which tend to be somewhat stronger. For example, Javorcik (2004) finds evidence of technological spillovers from FDI through backward linkages in firm-level Lithuanian data, from partly foreign owned firms to their domestic suppliers, but not from fully foreign-owned firms; while AlAzzawi (2011) finds a strong positive effect of both inward and outward FDI when a multinational corporation establishes a foreign subsidiary.

Overall, it appears that technology diffusion is facilitated by some forms of FDI, and by FDI in high-technology sectors. FDI may also promote growth through other channels than technology diffusion, such as reallocation of production to relatively productive sectors, and to relatively productive firms within sectors. More broadly, financial openness in general can promote growth, especially when such liberalization is combined with complementary institutional reform, which spurs domestic financial market development and fosters growth[4] (Beck & Levine 2005; Quinn & Toyoda 2008). Thus, capital flows may indeed be an important channel through which poles drive global growth.

It is likely that technological knowledge is generally difficult or impossible to codify fully, so that some technological knowledge remains tacit and can only be passed on from person to person (David 1993; Polanyi 1958). Theory has long suggested that labor mobility can promote knowledge spillovers (Arrow 1962), including between countries. Empirical evidence supports the hypothesis that both migration and short-term business travel facilitate diffusion of tacit technological knowledge. For example, Oettl & Agrawal (2008) find that international labor mobility not only promotes knowledge flows to the firms who hire immigrants, but also knowledge spillovers to other firms in the economy. Kim, Lee & Marschke (2009) study US firms access to non-U.S. R&D output by employing workers with foreign research experience, and find evidence that this is a significant channel for the diffusion of knowledge to the U.S.

[4]For a recent survey article on financial liberalization and growth, see Obstfeld (2009)

from foreign countries. Hovhannisyan & Keller (2010) analyze data on international business travel from the U.S. to 74 other countries, and find that it has an effect on innovation in these countries beyond the usual technology transfer through trade and FDI. The stock of migrants itself may also induce network effects from increased trade (Rauch 2001) and knowledge transfer (Kerr 2008; Kerr & Lincoln 2010). Even the fact of immigration can be a source of growth for the recipient nation, as migrants tend to be self-selected as industrious and seeking opportunity (McCraw 2010).

3 Empirical measures of growth polarity

3.1 Measure construction

The most straightforward measure of a growth pole is a given economy's contribution to global growth:

$$P_{it} = \frac{\Delta y_{it}}{Y_{t-1}}, \tag{1}$$

where y_{it} is the GDP of country i at time t, $Y_t = \sum_j^N y_{jt}$ is global GDP which simply aggregates GDP for all $N \in C$ countries, and $\Delta y_{it} \equiv y_{it} - y_{i,t-1}$ is the change in GDP of economy i. The above can be rewritten as

$$P_{it} = \frac{y_{i,t-1}}{Y_{t-1}} \cdot \frac{\Delta y_{it}}{y_{i,t-1}} \equiv s^y_{i,t-1} \cdot g^y_{i,t-1},$$

where s^y_{it} and g^y_{it} are the output share and growth rate of country i at time t, which means that a growth pole as defined in (1) is simply the size-adjusted growth rate of the economy. (1) is the standard approach to decomposing the relative contribution of each country to global growth. While intuitive and direct, such a measure would be incomplete. Critically, it fails to embody the manner by which growth poles exert their *polarity*, in the sense of capturing the transmission and spillover mechanisms for the country's growth to others in its economic space.

The natural extension of (1) is then to allow for such alternative channels of growth transmission, by replacing the size weight in (1) with weights corresponding to these channels. The literature has identified a range of alternative channels, and the theoretical justifications underpinning these different media was discussed in detail in Section 2. Here we list the different channels and propose empirical measures designed to capture these effects.

To capture the trade channel—which captures both the direct effect of absorption of other nations' exports, along with the indirect effect of facilitating technology transfer through trade linkages—a polarity measure of trade-related spillovers would be given by

$$P^T_{it} = \frac{m_{it}}{X_t} \cdot g^y_{it}, \tag{2}$$

where m_{it} is the total imports of country i at time t, and $X_t = \sum_j^N x_{jt}$ is total global exports.[5] Alternatively, if we concentrate on a broader measure of demand that is premised on domestic absorption, (2) becomes

$$P_{it}^{T\prime} = \frac{a_{it}}{X_t} \cdot g_{it}^{y},$$

where absorption $a_{it} = c_{it} + i_{it} + g_{it}$ is comprised of consumption c, investment i, and government spending g on goods and services, all for country i at time t.

The financial channel counterpart captures the direct effects of easing liquidity constraints in recipient economies, while also providing indirect benefits from increased leverage along with (again) technology transfer, and finance-related polarity can be defined as

$$P_{it}^{F} = \frac{fo_{it}}{FI_t} \cdot g_{it}^{y}, \tag{3}$$

where fo_{it} is the capital outflows from country i at time t, and $FI_t = \sum_j^N fi_{jt}$ is aggregate global capital inflows. Given the importance of FDI flows in knowledge and technology transfer, a natural (albeit narrower) alternative measure of (3) is

$$P_{it}^{F\prime} = \frac{fdi_{it}}{FDI_t} g_{it}^{y},$$

where fdi_{it} is *total* FDI (inflows and outflows) for country i at time t, and $FDI_t = \sum_j^N fdi_{jt}$ is total global FDI. The use of bidirectional FDI flows is consistent with the empirical evidence that FDI promotes technology transfer, regardless of its direction.

The migration channel not only serves to alleviate labor shortages, it can carry valuable human capital and embedded knowledge across borders, as well as yield network effects emanating to migrants' home countries. Migration-weighted polarity is defined as

$$P_{it}^{M} = \frac{\pi_{it}}{\Pi_t} \cdot g_{it}^{y}, \tag{4}$$

where π_{it} is the immigrant stock resident in country i at time t, and $\Pi_t = \sum_j^N \pi_{jt}$ is the sum of all migrants worldwide. It is possible, although not necessarily desirable, to limit (4) to only skilled labor emigration:

$$P_{it}^{M\prime} = \frac{\mu_{it}^{s}}{M_t^{s}} \cdot g_{it}^{y},$$

where migration in this case is limited to that of skilled labor, defined either in terms of Barro & Lee (1993)-style educational attainment, or more specifically in terms of workers in a certain profession (such as those located in the technological sector).

[5] An alternative specification would be to exclude country i from the measure, so that $X_t = \sum_{C\ i}^{N-1}$. While such an exclusion may be theoretically appealing in that it avoids self-referential spillovers, such calculations are problematic in practice. First, the calculated measure will no longer be directly comparable across different countries, since the weights applied will share different denominators. Second, the measure would also introduce bias toward larger exporters (since the denominator will now be smaller), and since large exporters are also likely to be large importers, the weights on these economies will be further distorted by these economies.

Finally, it is possible to attempt to measure the technological spillovers channel directly:

$$P_{it}^{A} = \frac{a_{it}}{A_t} \cdot g_{it}^{y}, \tag{5}$$

where a_{it} is a measure of technological spillovers by country i at time t, and $A_t = \sum_j^N a_{jt}$ is technological spillovers for the world as a whole. By and large, a_{it} is not directly observable. Nonetheless, it can be proxied by indicators such as total citations for a country's patents by foreigners, or more crudely by the total number of approved patents held by a given country (Hall, Jaffe & Trajtenberg 2001), or the total number of scientific articles published by residents of a given country.

3.2 Data sources and adjustments

We take the measures (1)–(5) to the data, drawing on long historical GDP data from Maddison (2003), and modern data from a combination of several alternative databases. The former dataset spans 1–2001, but since only output data are available, with substantial gaps, it is only used for the computation of (1) (and for illustrative purposes rather than formal analysis). The latter measures draw on data from the World Bank's World Development Indicators (output data) and Global Migration Database (migration data), the IMF's International Financial Statistics (financial data) and Direction of Trade Statistics (trade data), and an esoteric mix of science and technology databases, such as the WIPO Patentscope database and the NSF science and engineering indicators (technology data). These were then merged with a series of control variables obtained, among other sources, the WDI and IFS. These are described in detail in the technical appendix.

There are two possible candidate measures for the growth rate g_y. The most straightforward measure, which we apply as our benchmark, is the real growth rate, measured in constant 2000 U.S. dollars. However, over longer periods of time, such growth rates will be distorted by the Penn effect. Consequently, we also utilize the growth rate obtained from an output series that has been adjusted for purchasing power parity (PPP).

Since the focus of the polarity measures are on longer-term growth spillovers rather than cyclical factors, all candidate series were subsequently filtered with a Hodrik-Prescott filter to extract only the trend component (using $\lambda = 6.25$), before annual growth rates were calculated from this extracted trend.[6] Where necessary, the output series were interpolated in order to obtain unbroken series that would be amenable to the HP filter.

Several other variables were also cleaned to reduce the effects of idiosyncratic variation that would have exaggerated the weighting. For example, the trade data were corrected for reexports for the major entrepôt economies of Singapore, Hong Kong SAR, and the United Arab Emirates. The financial flows measure excludes derivative transactions, since these are

[6] Due to the substantial volatility present in the other data series, they were not similarly filtered, as doing so would have called for a very large smoothing parameter.

often more indicative of financial market turnover rather than actual growth-enhancing capital flows.

Annual values of (1)–(5) were then computed using each of these three candidate growth measures. To further smooth the final series, which may display excess annual variation due to the unfiltered weights, 5-year moving averages were calculated from the annual series. For the purposes of the regressions reported in Section 4, all variables were log-transformed.

3.3 Computations of growth polarity

Figure 1 plots the long historical evolution (Figure 1(a)) and modern economic history (Figure 1(b)) of the contribution to global growth (1), for a set of selected economies. As can be seen, China, Western Europe, and the United States have been important growth poles over the broad course of world history. Several features are notable. First, over the course of two millennia, there have been large swings in the polarities of the different countries/country groups; the evolution of polarity is marked by irregular cyclicality. Second, different countries have assumed the role of a dominant pole for global growth over time. In particular, China, the United States, and Western Europe (as a whole) have all had periods where their economies have been the primary driver of global growth. Third, the historical contributions of poles in the past are generally dominated, in absolute terms, by the contributions of more contemporary poles. Fourth, the general upward trend evident for many of the countries in Figure1(b) is indicative of the long-run acceleration of global growth that began early in the second millennium (with a second burst in the 1800s) and persisted through until the 1970s.

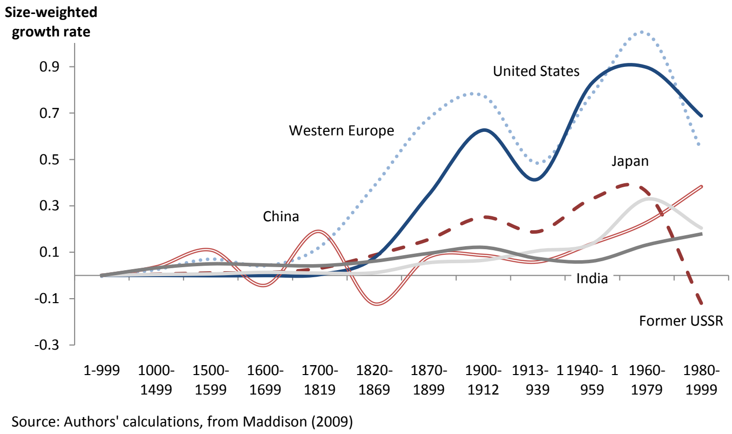
Finally, the trajectory of mature economies appears to be falling over time, while that of the emerging world, especially China, appears to be rising. This final stylized feature is clearest when examining the period of modern economic growth (Figure 1(b)). The major emerging economies all demonstrate flat or rising time trends, while the opposite holds for the mature economies.[7] Notably, China has increasingly become the prominent developing-country pole since the beginning of economic reform in the late 1970s and early 1980s under Deng Xiaoping.

Going beyond the simple measure, the other measures suggest that the specific weight employed in the computation of the polarity measure matters, since differences arise depending on the specific channel chosen. Table 1 reports the cross section of the top 10 economies as ranked under the different alternative polarity measures (2)–(5), using the 5-year average over 2004–2008.

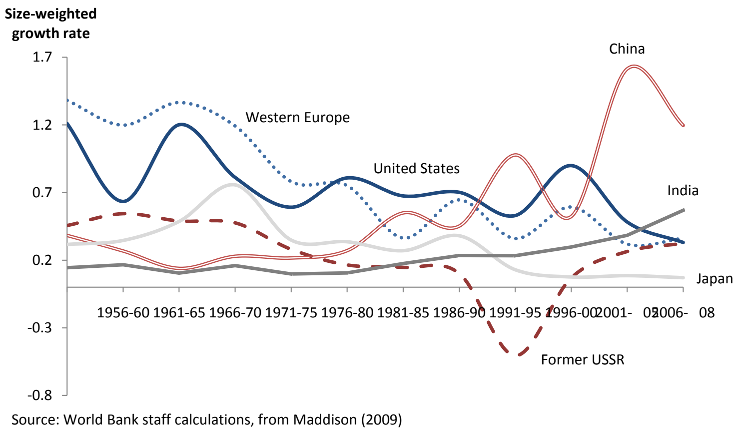
We gather four facts from this table. First, the specific polarity measure matters: for example, China—as the world's largest exporter—naturally arises as (far and away) the most significant trade growth pole, while the United States is the unquestioned technological leader.[8]

[7] Simple fitted linear trendlines for Germany, France, and Japan are downward sloping, while those for China, India, and Russia are upward sloping (Brazil's is flat).

[8] China's strong standing as a financial pole is perhaps somewhat surprising, and is driven by our decision to include reserve holdings in our capital flows measure. Absent reserve accumulation, which is arguably a relevant measure of financial strength and influence, the United Kingdom is elevated to the top financial pole, likely owing



(a) Long historical evolution



(b) Modern economic history

Figure 1: Time paths of selected economies according to contribution to global growth, 1–1999 (top panel) and 1951–2008 (bottom panel). Growth rate calculated as compound annual (five-year average annual) growth rate for the long historical (modern history) periods. Western Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Former USSR includes all successor republics of the former Soviet Union: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. The time series on the abscissa of Figure 1(a) is not scaled to constant intervals.

Second, there is some sensitivity of the polarity measure when measured by either real or PPP-adjusted growth rates. South Korea, in particular, tends to feature more prominently when the latter are utilized.

Third, secondary measures of related indicators corroborate, albeit imperfectly, the qualitative findings of the primary indicator. Capital flows, as measured by bilateral FDI and growth in real terms, place China (0.00563), Luxembourg (0.00262), the U.S. (0.00259), and the U.K. (0.00127) in the top four positions, very similar to the baseline capital flows measure. Likewise, using domestic absorption instead of imports to capture trade flows ranks the U.S. (0.00810), China (0.00736), Japan (0.00246), and India (0.00206) in the top pole positions (as measured by growth in PPP terms).[9] Indeed, correlations between these secondary indicators and the main ones employed, as reported in Table 2, are remarkably high, with perhaps the exception of the migration indicators.

Last, while the different measures tend to identity similar countries when the polarity measure is strong (which usually amounts to the top three countries by each measure), there is less definitiveness when the differences in polarity are more clustered. For example, despite Kazakhstan, Luxembourg, Jordan, and Singapore being relatively small countries, they feature strongly in some subindices. These tend to be rationalizable as either due to unique comparative advantages, or historical circumstance. Singapore and Luxembourg intermediate a large share of capital due to their roles as financial centers; this lends to their relatively strong showing according to the P^F measure. The higher showing of former Soviet republics such as Kazakhstan and Ukraine in the P^M measure is potentially of more concern, since much of the migratory flows in those cases were due to the exodus of labor in response to post-transition difficulties; such induced movement should perhaps be interpreted more a sign of economic weakness in the sending economy, rather than strength.

Table 2 is also suggestive of the importance of accounting for multiple channels of growth spillovers. The cross correlations between the different measures, while appreciable, are not excessively high. As such, each channel is likely to embody informational content that is not well captured by the other channels, which attests to the value of introducing various alternative measures.

3.4 An aggregate measure of growth polarity

In order to provide more definitiveness to the selection of growth poles (and reduce over-reliance on a single dimension), we generate an index based on the (first)[10] principal component for the collection of measures (2)–(5), which we label P^*.[11] The top 10 countries by this synthetic

to the position of London as a major global financial hub.

[9]Calculations for these secondary measures are available on request.

[10]The use of only the first component is verified by both scree and eigenvalue plots, which suggest that only the first component be included.

[11]Although principal components is our preferred aggregation methodology for producing the index, alternative aggregation mechanisms actually yield surprisingly similar results. The correlation between a simple average and the PCA measure is 0.99, and a similar correlation applies to a proportion-weighted average of the first two

Table 1: Top 10 countries according to alternative polarity measures, 2004–2008 period average, by nominal and PPP-adjusted GDP growth rates*

		P^T					P^F		
Rank	**Country**	**Real**	**Country**	**PPP**	**Rank**	**Country**	**Real**	**Country**	**PPP**
1	China	0.008	China	0.009	1	China	0.008	China	0.009
2	United States	0.003	United States	0.004	2	United States	0.002	United States	0.002
3	India	0.001	Germany	0.001	3	Luxembourg	0.002	Russia	0.002
4	South Korea	0.001	India	0.001	4	United Kingdom	0.002	Luxembourg	0.002
5	United Kingdom	0.001	United Kingdom	0.001	5	Russia	0.001	Ireland	0.002
6	Germany	0.001	South Korea	0.001	6	Ireland	0.001	France	0.001
7	Spain	0.001	Spain	0.001	7	France	0.001	Germany	0.001
8	Taiwan, China	0.001	Russia	0.001	8	Singapore	0.001	Singapore	0.001
9	Russia	0.001	Japan	0.001	9	Germany	0.001	Japan	0.001
10	Canada	0.001	France	0.001	10	Saudi Arabia	0.001	United Kingdom	0.001
		P^M †					P^A ‡		
Rank	**Country**	**Real**	**Country**	**PPP**	**Rank**	**Country**	**Real**	**Country**	**PPP**
1	United States	0.003	United States	0.005	1	United States	0.010	United States	0.012
2	Russia	0.003	Russia	0.004	2	Japan	0.002	Japan	0.004
3	India	0.002	India	0.002	3	Taiwan, China	0.002	Taiwan, China	0.002
4	China	0.002	China	0.002	4	Korea, Rep.	0.001	South Korea	0.002
5	Saudi Arabia	0.001	Ukraine	0.002	5	Germany	0.001	Germany	0.001
6	Kazakhstan	0.001	Saudi Arabia	0.001	6	China	0.001	China	0.001
7	Ukraine	0.001	Kazakhstan	0.001	7	Canada	0.000	Canada	0.001
8	Pakistan	0.001	UAE	0.001	8	United Kingdom	0.000	United Kingdom	0.000
9	UAE	0.001	Pakistan	0.001	9	France	0.000	France	0.000
10	Jordan	0.001	Jordan	0.001	10	Israel	0.000	Israel	0.000

* Authors' calculations. GDP data are from the World Development Indicators, and trade, finance, migration, and technology data are from DOT, IFS, Global Migration, and Patentscope database, respectively. Real GDP and PPP-adjusted indicate growth rates calculated using GDP data in 2000 U.S. dollars and constant 2005 international purchasing power parity-adjusted dollars.

† Migrant stocks are calculated from 2005 data, the only year available.

‡ Technological spillovers are measured using utility patents granted, for which the primary inventor is a resident of a given country.

Table 2: Correlation between primary and secondary weights, 1979–2010, in real GDP growth rates*

	P^T	$P^{T\prime}$	P^F	$P^{F\prime}$	P^A	$P^{A\prime}$	P^M	$P^{M\prime}$
P^{T}†	1.000							
$P^{T\prime}$‡	0.800	1.000						
P^F	0.575	0.674	1.000					
$P^{F\prime}$	0.592	0.758	0.546	1.000				
P^A	0.628	0.731	0.362	0.415	1.000			
$P^{A\prime}$	0.851	0.947	0.769	0.884	0.919	1.000		
P^M	0.581	0.579	0.289	0.425	0.550	0.730	1.000	
$P^{M\prime}$	0.533	0.318	0.278	0.331	0.090	0.252	0.369	1.000

* Authors' calculations, using data from the WDI, DOT, IFS, Global Migration, Patentscope, and NSF databases. Growth rates calculated from GDP data in real 2000 U.S. dollars.

† Main measures of trade, finance, technology, and migration computed from imports, financial outflows, patent citations, and immigrant stock.

‡ Secondary measures of trade, finance, technology, and migration computed from absorption, bilateral FDI, scientific articles, and skilled labor emigration.

measure, calculated with and without the inclusion of migration, and with both real and PPP growth rates, are reported in Table 3.[12]

The computed measures in this case are far more stable, and the two clearest poles to emerge are the United States and China. By and large, however, it appears that in addition to these two economies, a mix of advanced (Germany, Japan, the United Kingdom) and emerging (India, Russia, South Korea) economies share the role of being growth poles for the global economy, at least based on the 2004–08 period.

Table 3 captures several other interesting facts. First, it is important to recognize that the ordering of economies above are not one-for-one matches with economic size. Indeed, several large developed economies—such as Germany and France—appear several notches lower than their economic sizes alone would suggest; likewise, several emerging economies, in particular South Korea and Singapore, assume a greater weight than one would expect by GDP alone. Moreover, some regional heavyweights—such as Egypt and South Africa—do not appear in Table 3, likely because of their relatively small economic size (when measured at the global level), coupled with the fact that their growth spillovers are likely contained within their respective regions.

Finally, the uneven distribution of growth polarity is evident: The top two economies typically account for as much as 80 percent of the world total. This result has an interesting

factors.

[12]Migration is problematic for three reasons, which justifies our selective inclusion. First, the data are for the stock of migration, as opposed to the flow measures for the other indicators. Second, migration data are currently only available for one year, 2005. Third, as alluded to earlier, migration may capture not only positive spillover effects from a sending nation, but also the possibility of negative shocks in the sending nation, such as war, natural disasters, or economic crises.

Table 3: Top 10 countries identified by principal components, 2004–2008 period average, by real and PPP-adjusted GDP growth rates*

Rank	**Country**	**Real**	**Rank**	**Country**	**PPP**
		without migration			
1	China	8.174	1	China	10.853
2	United States	5.492	2	United States	7.344
3	South Korea	0.805	3	Japan	1.796
4	United Kingdom	0.752	4	Germany	1.331
5	Japan	0.746	5	Russia	1.208
6	India	0.608	6	United Kingdom	0.992
7	Germany	0.563	7	South Korea	0.945
8	Russia	0.459	8	France	0.926
9	France	0.390	9	India	0.685
10	Singapore	0.340	10	Ireland	0.674
		with migration†			
1	China	8.187	1	China	10.381
2	United States	6.998	2	United States	9.190
3	Russia	2.260	3	Russia	3.358
4	India	1.806	4	India	1.808
5	United Kingdom	0.761	5	Japan	1.560
6	Germany	0.646	6	Germany	1.505
7	South Korea	0.630	7	United Kingdom	1.126
8	Japan	0.560	8	France	0.986
9	Canada	0.499	9	Spain	0.850
10	Saudi Arabia	0.493	10	Saudi Arabia	0.795

* Authors' calculations, using data from the World Development Indicators. Index generated from first principal component of (1)–(5), variously excluding and including (4). Real GDP and PPP-adjusted indicate growth rates calculated from GDP data in real 2000 U.S. dollars and constant 2005 international purchasing power parity-adjusted dollars.
† Migration flows are calculated for 2005, the only year where data are available.

parallel in economic geography, where a small fraction of physical space typically accounts for a disproportionate share of economic activity. Thus, like would be the case for geographically-concentrated growth poles, global growth poles appear to follow a power law relationship (for cities, this relationship has been termed Zipf's Law).[13]

[13] Annex Figure A.2 illustrates this power law relationship. This non-normality in the key dependent variable also poses a potential problem for the regressions to follow; a linear logarithmic transform was thus applied to mitigate this concern, and residual diagnostics are discussed.

4 Factors underlying growth polarity

To better understand the phenomenon of growth poles, this section seeks to establish factors that underlie the aggregate measure P^* computed in Subsection 3.4. The most natural candidates for explanatory variables are those that have been suggested by the cross-country growth literature. Of course, the number of possible regressors number in the hundreds, and in spite of a large literature, there is little consensus on which variables are most reasonable to include.

We narrow the set of possible variables using two strategies. First, we limit the analysis to the variables that have been recognized as important by Bayesian averaging methods (Sala-i-Martin 1997; Sala-i-Martin, Doppelhofer & Miller 2004). These include factors that are likely to be *correlates*, rather than *determinants*, of growth polarity. Second, we seek to establish "deep" structural determinants that have been identified in the more recent growth literature (Rodrik *et al.* 2004). Accordingly, we classify the former category into proximate factors, and the latter into fundamental factors.

4.1 Estimation strategy

The proximate correlates regressions were performed using: (a) pooled ordinary least squares (OLS) with period dummies; (b) models with group effects; and (c) dynamic panel models. Pooled OLS is included primarily as a benchmark, although some variation across time is admitted through the period fixed effects. The approach thus provides a spotlight on how cross-sectional heterogeneity may affect growth polarity.

For the second class of estimators, we allow for two-way fixed effects, by country and time period. Random effects (RE) estimates were chosen over fixed effects (FE) if justified by a Hausman test, or if FE estimates were precluded due to the presence of time-invariant variables. By and large, this specification results in the application of the FE estimator; its findings thus rely on within-country variation over time. The main advantage of deploying models with group effects is that it better recognizes the role of unobserved heterogeneity in driving the results—important since we are uncertain about the appropriate proximate controls to include—although causal inference is compromised. The use of group effects models also means that we generally refrain from introducing additional dummy variables into the empirical model.

The third class of estimators explicitly provides for some (weak) control of endogeneity (at some cost to efficiency). Consequently, we regard these sets of estimates as most authoritative, although we recognize that the efficiency tradeoff may mean that fewer regressors appear as statistically significant (which may also occur as a result of proper accounting for endogeneity). System generalized method of moments (GMM) (Arellano & Bond 1991) was chosen over difference GMM (Arellano & Bover 1995) if Hansen tests suggest that the instruments are valid, or if (as before) time-invariant variables necessitated its use; otherwise difference GMM was implemented. Another added advantage of such models is the robustness of GMM estimates to violations of normality in the underlying data generation process, which may be a particular concern given the distribution of the main dependent variable.

The fundamental determinants regressions were run using: (a) instrumental variables (IV); and (b) system GMM. Since both of these methods are designed to address endogeneity issues, we are more confident about attributing causality in these cases. The IV estimates are performed for the 1999–03 cross section, and deployed using the following instruments: for institutions, settler mortality (IV-1) and fraction of European-language speaking population (IV-2) (Acemoglu, Johnson & Robinson 2001);[14] for integration, the gravity-predicted trade volume (Frankel & Romer 1999); for human capital, historical enrollment data from 1900 (Glaeser, La Porta, López-de Silanes & Shleifer 2004); and for democracy, the predicted level of democracy (Decker & Lim 2008). Both geography and social capital were treated as (plausibly) exogenous.

The same set of instruments is used for the dynamic panel estimates. Here, we exploit additional information available from the panel structure of the dataset to draw additional insight. We choose system GMM as the preferred estimation method, for two reasons: first, since we only have instruments available for one period, panel IV could not be used; second, the inclusion of geography as a primary time-invariant determinant rules out the use of difference GMM.

4.2 Benchmark results

Table 4 reports the results of the benchmark regressions for the proximate correlates of the aggregate growth polarity measure, computed from real GDP growth rates and excluding migration flows. The first three columns report the pooled OLS (*P1*), fixed or random effects (*P2*), and system or difference GMM (*P3*) estimates for the augmented Solow specification proposed in Mankiw, Romer & Weil (1992). The following three columns, (*P4*)–(*P6*), report coefficients from the same three estimation methodologies using a full specification that includes the major proximate variables of importance as identified by Sala-i-Martin *et al.* (2004).[15]

The benchmark results from the parsimonious specification given in (*P1*)–(*P3*) suggest that education, as captured by enrollment rates, may be an important correlate to growth polarity. Were this specification correct, educational levels would be positively related to the strength of an economy as a global growth pole. While this may be the case, there are reasons to believe that education may be capturing the effect, more generally, of per capita incomes (even after accounting for possible endogeneity via specification (*P3*)). This can be seen in specifications (*P4*)–(*P6*), where the inclusion of GDP per capita results in the enrollment variable falling out of statistical significance. Overall, the fit for the full specification is stronger, and post-regression diagnostics for the dynamic panel specifications (*P3*) and (*P6*) attest to the general validity of these estimates.[16]

[14] The latter set of instruments, although somewhat weaker, are often preferable because of greater data availability, which consequently increases the otherwise fairly small sample size.

[15] More precisely, the specification was chosen with an eye toward maximizing sample size and scope. Additional specifications that include variables that compromised this criterion are considered in the annex.

[16] Residual diagnostics also suggest that concerns about the distribution of the dependent variable were generally

Table 4: Benchmark regressions for proximate correlates of growth polarity, 1968–2008, with real GDP growth rates*

	P1	**P2**	**P3**	**P4**	**P5**	**P6**
Population growth	-2.078	-0.053	-1.827	2.767	2.304	-2.794
	(1.39)	(0.18)	(1.43)	(1.64)*	(1.41)	(2.33)
Investment	0.302	0.083	0.282	0.254	0.257	0.560
	(0.22)	(0.13)	(0.36)	(0.24)	(0.14)*	(0.37)
Enrollment	0.116	-0.037	0.335	-0.055	0.009	-0.063
	(0.04)***	(0.06)	(0.13)**	(0.04)	(0.05)	(0.12)
Income per capita				0.095	0.103	0.168
				(0.02)***	(0.02)***	(0.05)***
Life expectancy				-0.237	-0.361	-0.352
				(0.11)**	(0.19)*	(0.48)
Dependency ratio				-0.494	-0.442	0.032
				(0.12)***	(0.16)***	(0.30)
Government size				-0.887	-1.085	-1.545
				(0.23)***	(0.35)***	(0.68)**
Adjusted R^2	0.070			0.274		
F			2.709***			3.067***
Hansen J			31.644			60.344
AR(2)			-0.169			0.429
Estimator	OLS	RE	S-GMM	OLS	RE	S-GMM
Instruments			42			74
N	682	682	682	633	633	633

* Growth rates calculated from GDP data in real 2000 U.S. dollars. Sampling frame selected to maximize sample size, and is hence unbalanced. Data periodicity are five-year averages. All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A lagged dependent variable (GMM only), period fixed effects, and a constant term (all specifications) were included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

Indeed, per capita income appears to be strongly correlated with growth polarity. In some ways, this is not entirely surprising: economies that have historically been significant drivers of global growth are also generally the ones that have become developed, and this is reflected in the strong positive coefficient on the GDP per capita variable. The magnitude of this effect is relatively small, however, despite its strong statistical significance: a one percent increase in per capita income raises the polarity measure by about 0.1 percent.

Across the three specifications, a one percentage point increase in the size of government leads to a decrease in the polarity measure that ranges [0.9, 1.5] percent. This negative coefficient for government size should be interpreted in light of the fact that the specification already controls for per capita income levels. Since more developed economies tend, for political economy reasons, to have greater government expenditures as a result of more advanced social insurance programs (Iversen & Cusack 2000), they also possess, in general, larger governments. The

alleviated by the logarithmic transform. For the panel regressions, normal probability plots (shown in Figure A.3 the annex) suggest that non-normality in the residuals is not an issue (we refrain from formal statistical tests for the normality of errors in this case, since such tests are typically rejected for large sample sizes). The Kolmogorov-Smirnov test statistic was applied to the cross-section regressions that follow, however, and the results (available on request) are supportive of the normality of the error distribution.

negative influence of government size is thus independent of the level of development, and may be more indicative of inefficiencies associated with larger governments. There are theoretical (Meltzer & Richard 1981) and empirical (Sheehey 1993) reasons why government efficiency may fall after surpassing a given threshold for government size, and consequently contribute negatively to growth (and thus, indirectly, to growth polarity).[17][18]

The negative effect of the dependency ratio—a one percent increase reduces growth polarity by about 0.4 percent—is consistent with the notion that economies with a large, nonproductive population base are less likely to be dynamic drivers of global growth. Probing deeper into this variable suggests that the effect stems primarily from the size of the very young, rather than old, population: Regressions including both the child and aged dependency ratio rather than the total dependency ratio (reported in Table A.1) yields a (marginally) significant negative coefficient for the child dependency variable, but not the other. However, the burden of a large nonworking elderly population is not likely to be entirely innocuous. The coefficient on life expectancy is negative, and since economies with greater life expectancy will naturally have a larger old-age population, there are reasons to believe that aged dependency may play a role in reducing an economy's growth polarity. Overall, however, the effect of the dependency ratio is somewhat less robust, owing to the fact that controlling for weak endogeneity—in specification (*P6*)—does cause the variable to no longer be statistically significant.[19]

Turning to the fundamental determinants, Table 5 reports the benchmark regressions for the fundamental determinants of the aggregate growth polarity measure. The first three columns report the IV with instrument set IV-1 (*F1*), IV with instrument set IV-2 (*F2*), and system GMM (*F3*) estimates for the benchmark specification proposed in Rodrik *et al.* (2004). The following three columns, (*F4*)–(*F6*), report coefficients from the same three estimation methodologies using a fuller specification that includes democracy and ethnolinguistic fractionalization, both of which have been previously identified as fundamental variables of importance Alesina, Easterly, Devleeschauwer, Kurlat & Wacziarg (2003); Barro (1996). The final four columns include, alternately, two additional fundamental variables that were not included in the fuller specification because they would otherwise severely compromise the already-limited sample sizes: social capital (Knack & Keefer 1997) (columns (*F7*) and (*F8*)), and human capital (Glaeser *et al.* 2004) (columns (*F9*) and (*F10*)).

The benchmark results imply a very strong relationship between the quality of institutions and growth polarity. The coefficient on the institutions variable is statistically significant in 9 of

[17]We should recall that the variable measures government consumption, not investment. There is therefore no reason to believe that government investment, *per se*, would be less productive than private investment. Whether this is the case is an empirical question that is beyond the scope of this study.

[18]Regressions including an interaction term between income per capita and government size (not reported, but available on request) further corroborate this inference. The coefficient on the interaction term is negative and statistically significant (-0.733, p = 0.001), suggesting that the negative effect of a larger government is even greater at higher levels of development.

[19]Alternatively, the loss of efficiency in the GMM estimates vis-à-vis the group effects models may be responsible for the loss of statistical significance. In any case, we regard all proximate regressions as largely indicative of correlates, rather than determinants, and accordingly do not place as much weight on the causal mechanisms here.

Table 5: Benchmark regressions for fundamental determinants of growth polarity, 1999–2003 and 1968–2008, with real GDP growth rates*

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
Institutions	2.374	3.627	1.71	2.430	5.584	1.597	6.193	1.454	2.679	1.457
	(0.85)***	(1.67)**	(0.39)***	(0.80)***	(2.92)*	(0.47)***	(2.86)**	(0.50)***	(4.75)	(0.37)***
Integration	-0.555	-0.667	-0.144	-0.510	-0.889	-0.195	-0.739	-0.190	-0.365	-0.168
	(0.23)**	(0.27)**	(0.17)	(0.25)**	(0.41)**	(0.14)	(0.34)**	(0.14)	(0.27)	(0.13)
Geography	-0.126	-0.216	-0.050	-0.118	-0.295	-0.013	0.092	-0.032	-0.690	-0.012
	(0.09)	(0.17)	(0.04)	(0.11)	(0.23)	(0.08)	(0.27)	(0.07)	(0.96)	(0.04)
Democracy				-0.058	-0.563	-0.157	-1.387	-0.134	2.992	-0.094
				(0.32)	(0.46)	(0.26)	(1.04)	(0.23)	(2.73)	(0.16)
Fractionalization				0.701	1.037	0.099	1.598	0.045	0.729	0.126
				(0.39)*	(0.74)	(0.37)	(1.07)	(0.39)	(0.83)	(0.27)
Social capital							-2.971	0.334		
							(2.12)	(0.62)		
Human capital									0.535	0.089
									(1.28)	(0.12)
F			3.778***			1.850*		1.676		2.273**
Anderson LR	9.826***	5.750*		9.388***	3.446		3.245		1.281	
Hansen *J*		1.687	74.473		0.034	40.754	0.027	33.795	0.445	64.921
AR(2)			-1.473			-1.398		-1.555		-1.410
Estimator	IV-1	IV-2	S-GMM	IV-1	IV-2	S-GMM	IV-2	S-GMM	IV-2	S-GMM
Instruments	2	3	82	3	4	98	4	98	5	124
N	42	75	352	37	69	204	40	204	33	344

* Growth rates calculated from GDP data in real 2000 U.S. dollars. Sampling frame selected to maximize sample size, and is hence unbalanced. Data periodicity five-year averages for 1999–2003 (cross-section) and 1968–2008 (panel). All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A lagged dependent variable (GMM only) and a constant term (all specifications) were included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

the 10 specifications, and economically significant as well: estimates of the change in growth polarity is bounded by $[0.8, 4.3]$ percent, for every one percent improvement in institutional quality. Moreover, postestimation tests suggest that, for cases where the specification is overidentified, the instruments satisfy the exclusion restriction (Sargan-Hansen statistics are not significant). Underidentification tests, however, are more problematic, especially when the sample size is small—notably in specifications (*F7*) and (*F9*)—with Anderson statistics indicating that not all included instruments are relevant. Taken together, however, we remain modestly confident in attributing a causal effect of institutions on growth polarity.

Integration enters with a negative and significant coefficient in a number of specifications, especially when estimated using IV. Although somewhat counterintuitive at first glance—trade openness has, after all, often been regarded as an important determinant of economic growth—it is important to remember that the growth polarity measure captures not only growth, *per se*, but the global spillover effects of such growth. Hence, even when considering the trade channel alone—as summarized by, for example, (2)—it is the *absolute* size of trade relative to global trade, as opposed to the volume of trade relative to the economy's size. This means that larger economies will (owing to a gravity-type explanation) generally have a greater trade channel impact *even if they are relatively closed* and, *mutatis mutandis*, greater growth polarity. Indeed, comparing the relative ranking of absolute trade impact to that of trade openness (given in annex Table A.6) reveals that open economies are not necessarily the ones with the greatest global impact.

Another way to interpret this result is to recognize that global growth poles are likely to have a strong internally-driven growth engine—owing mainly to domestic demand—rather than externally-led forces. Only through robust domestic consumption and investment can we expect the economy's growth to be sustainable, and spill over at the global level, rather than reliant on the forces of external demand for its exports.

The other fundamental variables appear to be insignificant determinants of growth polarity. Some caution is warranted, however, owing to the very limited country coverage of the instruments (which in turn limits the sample size). For example, regressions that limit the estimates to only institutions, integration, geography, and human capital, and using the settler mortality instrument, indicate that human capital could actually exert a positive and marginally significant impact on growth polarity (to the exclusion of institutions).[20] Moreover, the relatively poor goodness of fit (as captured in the F test) also suggest that the results in (*F6*) and (*F8*) should be interpreted judiciously.

[20]These are not reported but the results are available on request. We are somewhat agnostic about these estimates in part because of concerns of micronumerosity (a very small sample size of 15), but results such as these justify our call for the exercise of caution.

5 Multipolarity: The distribution of growth polarity

5.1 Concentration indices

To better understand the evolution of growth polarity over time, especially in terms of growth poles at the global level, we require some index that captures the relationship between the poles, especially the major ones. One such measure would be a concentration index. There are three common measures of economic concentration, or resource-based power. The most popular of these is the Herfindahl-Hirschman index (Hirschman 1964), which is a sum of the squared shares of P^*:

$$H_t = \sum\nolimits_{J(t)} \left(\frac{P^*_{jt}}{\sum_{J(t)} P^*_{jt}} \right)^2 \equiv \sum\nolimits_{J(t)} r_{jt},$$

where r_{jt} is the relative polarity share of country j at time t, and $J(t)$ is the set of $N = 15$ economies with the highest P^* measure at time t. This index may be further normalized so that the index is bound by $[0, 1]$:

$$H^*_t = \frac{H_t - \frac{1}{N}}{1 - \frac{1}{N}}. \tag{6}$$

This measure is essentially equivalent to the well-known Ray-Singer concentration index (Ray & Singer 1973), popularized by Mansfield (1993):

$$C_t = \sqrt{\frac{\sum_{j=1}^{N} c^2_{jt} - \frac{1}{N}}{1 - \frac{1}{N}}}.$$

where c_{it} is in this case defined as the share of aggregate "capabilities" of a given power i at time t. However, the literature often treats capabilities in terms of straightforward economic size, rather than potential influence as captured by economic spillovers.

Another related concentration index is the Theil, which weights polarity shares by the average polarity share:

$$T_t = \frac{1}{N} \sum\nolimits_{J} \left(\frac{P^*_{jt}}{\bar{P}^*{}_t} \cdot \ln \frac{P^*_{jt}}{\bar{P}^*{}_t} \right),$$

where $\bar{P}^*{}_t \equiv \sum_J P^*_j / N$ is the mean of the polarity measure in the top 15 economies. This can likewise be normalized to

$$T^*_t = \frac{T_t}{\ln N}. \tag{7}$$

One advantage of considering these two indices in tandem is that they possess properties that render the former more sensitive to changes in large economies, and the latter more sensitive to changes in small economies.[21] However, dispersion has often been summarized by way of a Gini coefficient:

$$G^*_t = \frac{\sum_J \sum_{-j} \left| P^*_{jt} - P^*_{-jt} \right|}{2N^2 \bar{P}^*{}_t}, \tag{8}$$

[21] This results from the fact that H (T) is convex (concave) on total polarity shares.

where the subscript, $-j$, indicates all economies other than j. As is the case for the normalized expressions (6) and (7), (8) ranges from 0 to 1, with lower values indicating greater dispersion.

Table 6 reports the three concentration indices (6)–(8) for selected period averages, with growth polarity computed from the same four permutations in Table 3. It is clear that, regardless of the underlying polarity measure chosen, concentration has fallen over time. Importantly, this has occurred over the relatively short period spanned by the sample considered. This overall decline is well captured in Figure 2, which plots three alternative concentration measures corresponding to the benchmark aggregate growth polarity measure, computed from real GDP growth rates and excluding migration flows.

Table 6: Concentration indices, selected period averages, by real and PPP-adjusted GDP growth rates[*]

	H^*	T^*	G^*	H^*	T^*	G^*
		Real			**PPP**	
			without migration			
1984–88	0.00583	0.01284	0.12603	0.02287	0.04682	0.25557
1994–98	0.00504	0.01064	0.09900	0.01995	0.03733	0.20204
2004–08	0.00334	0.00751	0.08268	0.01640	0.03294	0.19090
		Real			**PPP**	
			with migration			
1984–88	0.01667	0.02288	0.17114	0.03513	0.05369	0.27763
1994–98	0.01059	0.02088	0.14169	0.02682	0.04824	0.22984
2004–08	0.00569	0.01261	0.11994	0.01726	0.03574	0.21274

[*] Authors' calculations, using data from the World Development Indicators. Index generated from first principal component of (1)–(5), variously excluding and including (4). Real GDP and PPP-adjusted indicate growth rates calculated from GDP data in real 2000 U.S. dollars and constant 2005 international dollars.

[†] Migration flows are calculated for 1985, 1995, and 2005, respectively, the years where data are available.

5.2 Toward a multipolar world

What do the changing polarities mean for the distribution of economic influence in the global economy as a whole? To the extent that growth polarity is an accurate measure of such influence, the results in the previous section suggest that multipolarity increased steadily through the end of the Cold War, fell during the final decade of the 20th century, and finally rose again in the first decade of the 21st century; indeed, over the past decade, the world has attained some of the most diverse distributions since 1968.[22]

[22]The sharp decline in the early 1970s deserves some comment. This fall is a function of several factors. Most crucially, the industrial economies underwent major recessions resulting from the first oil shock in 1973 (reinforced

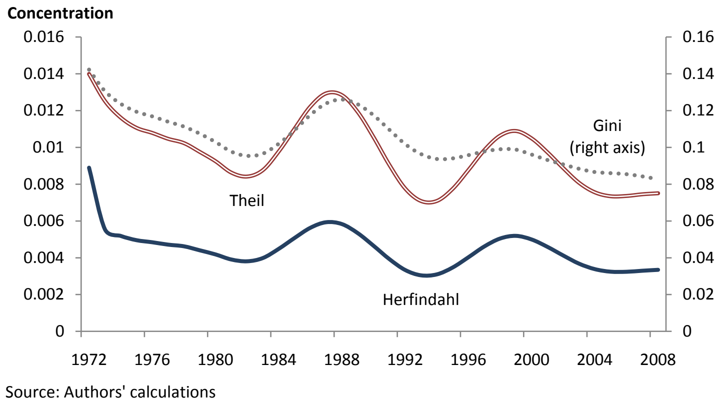


Figure 2: Concentration measures for growth polarity shares of top 15 economies, 1972–2008, smoothed by taking rolling five-year averages. Polarity shares are calculated from the real GDP growth rate. All three measures have trended downward since the mid-1970s

Thus, the world has steadily become increasingly multipolar. This rising multipolarity has occurred in concert with the expansion of globalization. Indeed, history tells us that successive waves of economic globalization typically have wrought periods of greater economic multipolarity, along with concomitant frictions due to changes in the global configuration of geopolitical power (Findlay & O'Rourke 2007).

Concurrent with this rising multipolarity has been a shift away from the G-7 economies as global growth drivers, toward the economies of the developing world. This shift partly explains why the postfinancial crisis global environment has been marked by a sharp rise in international economic tensions, with heightened protectionist sentiment, accusations of exchange rate manipulation, and talk of trade collapse and currency wars.

Yet a deeper examination of the changes in the growth polarity indexes underlying Figure 2 suggests that the dynamics of what is captured in the figure are due not so much to a decline of developed economies (although some absolute decline, especially in the early 1970s, indeed occurred), but rather to a rise in the growth polarities of developing economies. Moreover, while structural changes in both the advanced and emerging world possibly could alter this dynamic, the overall trend toward a more multipolar world seems unlikely to change.

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by the second in 1979). This negative shock was felt worldwide by all countries (apart from oil exporters), but the slowdown was more severe for the industrial world, which had relatively larger economies at the time. This resulted in a significant reduction in their respective growth polarities, and hence a corresponding decrease in the concentration indices. A secondary reason is that data coverage in the earlier years was not as comprehensive, and to the extent that higher polarity countries are omitted, the polarity share P^* used in calculations of (6)–(8) would have been affected. An examination of the distribution of the polarity index during this time suggests, however, that this latter concern is likely to be less of an issue, because the decline in the Herfindahl-Hirschman appears to be driven more by a significant reduction in the polarity value for the major economies of the euro area and the United States, rather than the introduction of high-polarity economies as the sample coverage improved.

6 Conclusion

There is no definitive method to accurately measure the polarity effects that a country exerts on the other countries in the world economy. This paper has sought to provide a range of empirically-grounded measures that capture the spillover effects that emanate from growth poles, while accounting for the effect of the growth rate of the country in question relative to the global economy. While the identified poles and potential poles are consistent with the economies that have dominated the discussion in the literature (Buiter & Rahbari 2011; OECD 2010; O'Neill 2001; Wilson & Stupnytska 2007), the quantitatively-based selection methodology of the current approach also identifies some unexpected poles, while providing a sense of the magnitude of each pole.

Furthermore, the study of the proximate correlates and fundamental determinants of growth polarity point to the likely character of such poles: that they are dynamic economies that have a high-quality institutional framework and strong internal demand, and in possession of a relatively small nonworking population and efficient government. They are also, more likely than not, to have higher levels of income, although whether this characteristic will persist is in doubt, given the strong representation of developing countries in Table 3.

Future directions include applications of the polarity measure and multipolarity indices to outstanding questions in development and international political economy. As two examples, the growth polarity measure can be included as an explanatory variable in cross-country growth regressions to examine the extent of growth spillovers generated from global growth poles, and the multipolarity index can be included in regressions that examine the changing governance structures of international organizations.

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Technical Appendix

A.1 Data sources

measured respectively by imports as a share of global exports, capital outflows as a share of global inflows, and patents as a share of global patents. The imports measure corrects for re-exports for the major entrept economies of Singapore and Hong Kong, and for intra-monetary union trade using bilateral trade flows data. The capital outflows measure includes FDI and portfolio capital, but excludes derivative transactions. The patents measure utilizes patent approvals to all national patent bodies reporting to the World Intellectual Property Office. The expanded polarity measure additionally includes weights for the migration channel, as measured by immigrant stock as a share of global immigrants.

Population growth was measured as the growth rate of the total population, *investment* was gross fixed capital formation share of GDP, *enrollment* was the primary school enrollment rate, *income per capita* was real per capita GDP measured in 2000 U.S. dollars, *health status* was the life expectancy of the population, the *dependency ratio* is ratio of the population younger than 15 or greater than 65 relative to the working age population, and *government size* was the government expenditure share of GDP. Alternative measures for enrollment, health, and dependency used were the secondary school enrollment rate, the under-5 mortality rate, and the old-age dependency ratio. Additional controls: *Technology diffusion* was proxied by mobile cellular subscriptions coverage, *infrastructure* by road density, and the regional dummies included *Africa*, *Latin America*, and *East Asia*.

The measure of *institutional quality* was a composite measure obtained by taking the proportion-weighted sum of the first three principal components of 11 subcomponents of the ICRG political risk measure: government stability, corruption, law and order, bureaucracy quality, socioeconomic conditions, investment profile, internal conflict, external conflict, military in politics, religious tensions, and ethnic tensions (only the first three components obtained an eigenvalue greater than unity, justifying their inclusion). Alternative institutional quality measures applied: (a) inclusion of democratic accountability to the subcomponents used in the principal components analysis; (b) restriction of the measure to only the first four subcomponents (and taking the proportion-weighted sum of only the first two principal components); and (c) restriction of the measure to only the first four subcomponents (but weighting each subcomponent equally). *Economic integration* was total trade (imports plus export) as a share of GDP, and *geography* was the latitudinal distance from the equator.

A.2 Additional figures

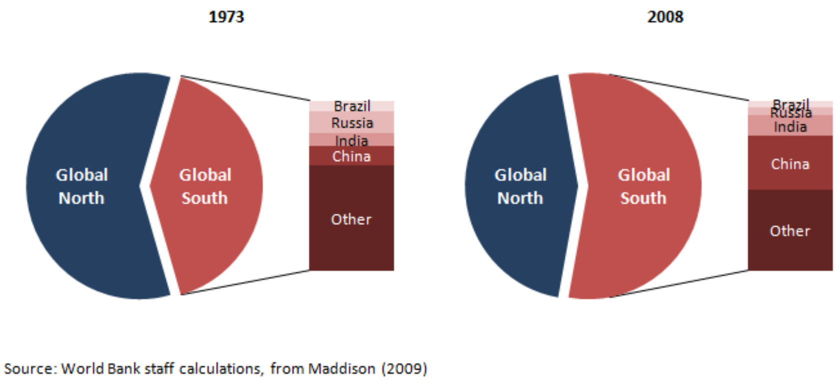
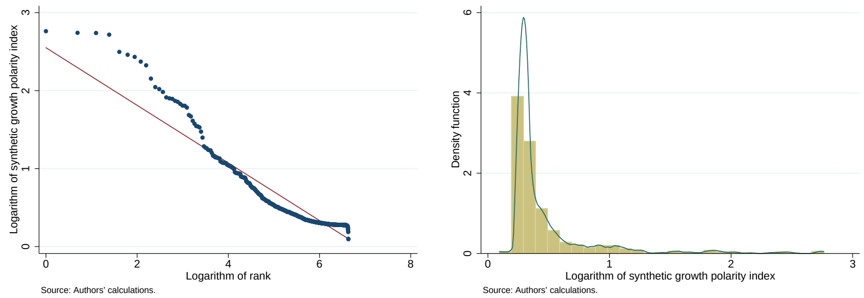


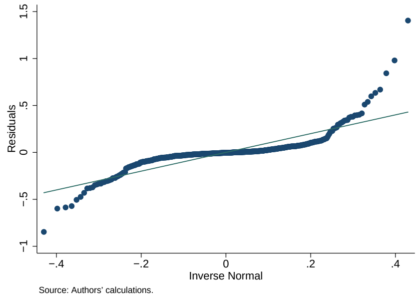
Figure A.1: Shares of global GDP, Global North and South, 1973 and 2008. The ceding of economic share from the North to the South is clearly evident, with the increase largely led by China. Within emerging economies, India has also grown relative to Russia.



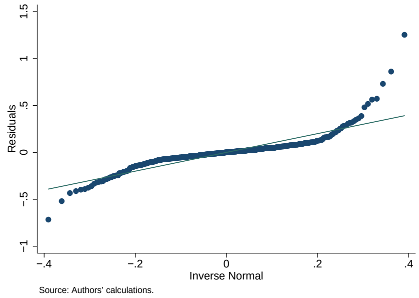
(a) Power distribution

(b) Histogram and kernel density

Figure A.2: Log-log plot of rank-synthetic growth polarity index distribution (without migration), real GDP growth rates (left panel), and histogram of synthetic polarity index and superimposed kernel density estimate (right panel). The former illustrates the power law-type distribution, with a scaling exponent of -2.4. The latter captures the density of the log-transformed distribution, which remains right-skewed but less so than an untransformed distribution.



(a) Q-Q residual plot, (*P2*)



(b) Q-Q residual plot, (*P5*)

Figure A.3: Quantile plot of residuals for specifications (*P2*) and (*P5*). The clustering of most residuals around the 45-degree line corresponding to the theoretical normal distribution suggests a reasonable fit (and hence normality of residuals), although some outliers are clearly apparent.

A.3 Additional tables

Table A.1 reports robustness results for the proximate correlates of the aggregate growth polarity measure. Odd-numbered specifications are coefficient estimates using group effects models, while even-numbered specifications are estimates using dynamic panel models. The top panel introduces additional variables for: (*R1*)–(*R2*) technology coverage; (*R3*)–(*R4*) infrastructure quality; and (*R5*)–(*R6*) regional dummies. The bottom panel substitutes measures for: (*R7*)–(*R8*) primary with secondary enrollment; (*R9*)–(*R10*) life expectancy with the under-5 mortality rate; and (*R11*)–(*R12*) the total dependency ratio with the child and aged dependency ratios.

By and large, the coefficients on the main variables that were found to be significant in benchmark Table 4 retain their expected signs and statistical significance. The additional variables introduced in the top panel are generally not significant (which partly justifies their exclusion from the benchmark), with perhaps the exception the Latin America dummy. The marginally statistical significant coefficient on the under-5 mortality variable in specificaiton (*R10*) is consistent with the fact that a higher child mortality rate would also mean a lower child dependency ratio, which enters with a negative coefficient in specification (*R11*).

Several additional variables do enter as statistically significant in some specifications, and when they do, they generally do so with the *ex ante* expected signs. For example, a positive and significant coefficient on investments appears in several specifications, as does population growth (although the sign on this latter variable is somewhat less stable).

Table A.1: Robustness regressions for proximate correlates of growth polarity, 1968–2008, with real GDP growth rates*

	R1	**R2**	**R3**	**R4**	**R5**	**R6**
Population	0.718	-1.428	0.407	0.760	0.521	-7.140
growth	(0.94)	(1.80)	(0.62)	(1.59)	(1.03)	(3.20)**
Investment	0.171	0.456	0.285	0.418	0.468	0.904
	(0.13)	(0.35)	(0.19)	(0.28)	(0.15)***	(0.41)**
Enrollment	0.019	0.174	0.077	-0.120	0.099	-0.126
	(0.05)	(0.15)	(0.04)**	(0.17)	(0.07)	(0.14)
Income per	0.142	0.179	0.087	0.180	0.108	0.127
capita	(0.05)***	(0.07)**	(0.03)***	(0.07)**	(0.03)***	(0.06)**
Life	-0.187	-1.177	-0.222	-1.389	-0.243	0.096
expectancy	(0.16)	(0.65)*	(0.19)	(0.66)**	(0.18)	(1.04)
Dependency	-0.493	-0.092	-0.367	-0.546	-0.530	-0.086
ratio	(0.17)***	(0.33)	(0.19)*	(0.44)	(0.20)***	(0.43)
Government	-0.628	-1.311	-1.300	-1.501	-0.850	-1.743
size	(0.24)**	(0.66)**	(0.44)***	(0.62)**	(0.25)***	(0.64)***
Technology	-0.030	-0.036				
	(0.02)	(0.03)				
Infrastructure			0.005	-0.081		
			(0.03)	(0.15)		
Africa					0.083	0.052
					(0.09)	(0.26)
Latin America					-0.098	-0.149
					(0.06)*	(0.06)**
East Asia					0.033	-0.003
					(0.06)	(0.14)
F		3.421***		2.696***		4.312***
Hansen *J*		67.345		70.913		55.126
AR(2)		-1.811*		-1.418		-1.017
Estimator	FE	S-GMM	RE	S-GMM	RE	S-GMM
Instruments		79		74		77
N	611	611	261	261	489	489

	R7	**R8**	**R9**	**R10**	**R11**	**R12**
Population	2.570	-2.668	16.343	20.984	0.257	-1.613
growth	(1.47)*	(2.34)	(8.94)*	(14.14)	(1.57)	(2.23)
Investment	0.274	0.548	0.512	-1.994	0.344	0.539
	(0.15)*	(0.36)	(0.75)	(1.81)	(0.14)**	(0.39)
Enrollment			-0.252	-0.047	-0.019	-0.084
			(0.52)	(1.16)	(0.04)	(0.13)
Income per	0.110	0.158	0.498	0.416	0.121	0.145
capita	(0.02)***	(0.05)***	(0.15)***	(0.19)**	(0.03)***	(0.05)***
Life	-0.460	-0.637			-0.184	-0.067
expectancy	(0.19)**	(0.44)			(0.21)	(0.43)
Dependency	-0.441	-0.056	-0.132	-1.106		
ratio	(0.16)***	(0.29)	(0.65)	(0.74)		
Government	-1.158	-1.536	-1.293	0.735	-1.152	-1.596
size	(0.36)***	(0.70)**	(1.25)	(1.65)	(0.37)***	(0.68)**
Secondary	0.024	0.049				
enrollment	(0.03)	(0.06)				
Under-5			0.246	0.523		
mortality			(0.34)	(0.27)*		
Child dependency					-0.162	0.125
ratio					(0.09)*	(0.22)
Aged dependency					-0.083	0.129
ratio					(0.10)	(0.12)
F		2.867***		3.001***		3.292***
Hansen *J*		66.120		14.671		60.716
AR(2)		0.548		-0.258		0.380
Estimator	RE	S-GMM	FE	S-GMM	RE	S-GMM
Instruments		74		64		82
N	608	608	203	203	633	633

* Growth rates calculated from GDP data in real 2000 U.S. dollars. Sampling frame selected to maximize sample size, and is hence unbalanced. Data periodicity are five-year averages. All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A lagged dependent variable (GMM only), period fixed effects, and a constant term (all specifications) were included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

Tables A.2 and A.3 report, without comment, the analogous benchmark results for Tables 4 and 5, but with the aggregate growth polarity measure using PPP growth rates. By and large, the results presented in these two tables are qualitatively similar to the measure using real growth rates. Due to the more limited coverage of the PPP series, the regressions are for a smaller sample.

Table A.2: Benchmark regressions for proximate correlates of growth polarity, 1981–2008, with PPP GDP growth rates*

	AP1	**AP2**	**AP3**	**AP4**	**AP5**	**AP6**
Population	-1.176	-0.092	-0.046	-0.313	-0.357	-2.865
growth	(1.02)	(0.21)	(0.28)	(1.17)	(1.12)	(2.23)
Investment	0.164	-0.028	-0.122	0.206	0.055	0.360
	(0.16)	(0.11)	(0.14)	(0.18)	(0.13)	(0.21)*
Enrollment	0.103	0.024	-0.012	-0.002	0.027	-0.050
	(0.03)***	(0.04)	(0.10)	(0.03)	(0.04)	(0.08)
Income per				0.058	0.041	0.106
capita				(0.02)***	(0.02)**	(0.03)***
Life				-0.214	-0.182	-0.286
expectancy				(0.07)***	(0.09)**	(0.32)
Dependency				-0.240	-0.328	0.037
ratio				(0.08)***	(0.09)***	(0.15)
Government				-0.681	-0.423	-0.673
size				(0.18)***	(0.18)**	(0.25)***
Adjusted R^2	0.013			0.167		
F			1.660			3.056***
Hansen J			62.669			71.109
AR(2)			-0.634			-0.487
Estimator	OLS	RE	D-GMM	OLS	RE	S-GMM
Instruments			58			70
N	592	592	451	555	555	555

* Growth rates calculated from GDP data in constant 2005 international purchasing power parity-adjusted dollars. Sampling frame selected to maximize sample size, and is hence unbalanced. Data periodicity are five-year averages. All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A lagged dependent variable (GMM only), period fixed effects, and a constant term (all specifications) were included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

Table A.3: Benchmark regressions for fundamental determinants of growth polarity, 1999–2003 and 1981–2008, with PPP GDP growth rates*

	AF1	**AF2**	**AF3**	**AF4**	**AF5**	**AF6**	**AF7**	**AF8**	**AF9**	**AF10**
Institutions	1.441	2.471	0.896	1.467	3.778	1.045	4.330	0.94	2.096	0.794
	(0.56)***	(1.13)**	(0.27)***	(0.54)***	(1.98)*	(0.32)***	(1.99)**	(0.33)***	(3.36)	(0.23)***
Integration	-0.354	-0.450	-0.038	-0.323	-0.600	-0.145	-0.513	-0.142	-0.251	-0.060
	(0.15)**	(0.18)**	(0.09)	(0.17)*	(0.27)**	(0.09)	(0.24)**	(0.09)	(0.19)	(0.09)
Geography	-0.076	-0.158	-0.009	-0.074	-0.206	-0.019	0.071	-0.031	-0.546	0.002
	(0.06)	(0.11)	(0.03)	(0.08)	(0.16)	(0.05)	(0.19)	(0.05)	(0.68)	(0.02)
Democracy				-0.014	-0.402	-0.066	-1.010	-0.051	2.042	-0.112
				(0.21)	(0.31)	(0.17)	(0.72)	(0.16)	(1.93)	(0.11)
Fractionalization				0.415	0.704	0.041	1.135	0.002	0.411	0.067
				(0.26)	(0.50)	(0.25)	(0.75)	(0.27)	(0.58)	(0.19)
Social capital							-2.158	0.235		
							(1.48)	(0.40)		
Human capital									0.302	0.140
									(0.90)	(0.10)
F			2.743***			1.497		1.416		2.012**
Anderson LR	9.826***	5.750*		9.388***	3.446		3.245		1.281	
Hansen J		1.599	58.865		0.088	31.420	0.026	32.775	0.368	61.961
AR(2)			-1.311			-1.399		-1.530		-1.623
Estimator	IV-1	IV-2	S-GMM	IV-1	IV-2	S-GMM	IV-2	S-GMM	IV-2	S-GMM
Instruments	2	3	67	3	4	83	4	83	5	109
N	42	75	353	37	69	204	40	204	33	345

* Growth rates calculated from GDP data in constant 2005 international purchasing power parity-adjusted dollars. Sampling frame selected to maximize sample size, and is hence unbalanced. Data periodicity five-year averages for 1999–2003 (cross-section) and 1981–2008 (panel). All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A lagged dependent variable (GMM only) and a constant term (all specifications) were included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

Tables A.4 and A.5 report, without comment, the analogous benchmark results for Tables 4 and 5, but with the aggregate growth polarity measure computed with migration flows (and using real GDP growth rates). By and large, the results presented in these two tables are qualitatively similar to the measure using real growth rates.

Table A.4: Benchmark regressions for proximate correlates of growth polarity (with migration), 1968–2008, with GDP growth rates*

	BP1	**BP2**	**BP3**	**BP4**	**BP5**	**BP6**
Population growth	-2.246	-0.233	-4.173	2.958	1.465	-0.917
	(0.75)***	(0.54)	(1.68)**	(1.00)***	(0.88)*	(1.25)
Investment	0.061	-0.050	-0.001	0.047	0.091	0.269
	(0.12)	(0.11)	(0.14)	(0.13)	(0.10)	(0.19)
Enrollment	-0.003	-0.039	0.004	-0.060	-0.028	-0.043
	(0.02)	(0.04)	(0.05)	(0.03)**	(0.04)	(0.07)
Income per capita				0.040***	0.052	0.093
				(0.01)	(0.02)***	(0.03)***
Life expectancy				-0.082	-0.212	-0.197
				(0.07)	(0.10)**	(0.29)
Dependency ratio				-0.287	-0.224	0.017
				(0.07)***	(0.09)**	(0.16)
Government size				-0.629	-0.820	-1.154
				(0.19)***	(0.24)***	(0.40)***
Adjusted R^2	0.051			0.179		
F			2.602***			3.233***
Hansen J			74.043			57.330
AR(2)			-0.626			-0.527
Estimator	OLS	RE	S-GMM	OLS	RE	S-GMM
Instruments			74			74
N	673	673	673	628	628	628

* Growth rates calculated from GDP data in constant 2005 international purchasing power parity-adjusted dollars. Sampling frame selected to maximize sample size, and is hence unbalanced. Data periodicity are five-year averages. All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A lagged dependent variable (GMM only), period fixed effects, and a constant term (all specifications) were included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

Table A.5: Benchmark regressions for fundamental determinants of growth polarity (with migration), 1999–2003 and 1968–2008, with real GDP growth rates*

	BF1	**BF2**	**BF3**	**BF4**	**BF5**	**BF6**	**BF7**	**BF8**	**BF9**	**BF10**
Institutions	1.364	2.037	0.659	1.383	3.335	0.832	3.581	0.724	1.993	0.640
	(0.51)***	(0.94)**	(0.23)***	(0.48)***	(1.71)*	(0.32)**	(1.64)**	(0.33)**	(2.87)	(0.22)***
Integration	-0.344	-0.396	-0.198	-0.303	-0.543	-0.224*	-0.442	-0.221	-0.268	-0.179
	(0.14)**	(0.15)***	(0.13)	(0.15)**	(0.24)**	(0.11)*	(0.19)**	(0.12)*	(0.16)	(0.11)*
Geography	-0.071	-0.135	-0.015	-0.062	-0.181	0.001	0.073	-0.013	-0.498	0.011
	(0.06)	(0.09)	(0.03)	(0.07)	(0.14)	(0.06)	(0.16)	(0.05)	(0.58)	(0.03)
Democracy				-0.010	-0.365	-0.093	-0.863	-0.075	1.721	-0.086
				(0.19)	(0.27)	(0.16)	(0.59)	(0.14)	(1.65)	(0.08)
Fractionalization				0.446	0.722	0.219	1.104	0.179	0.506	0.125
				(0.23)*	(0.43)*	(0.20)	(0.62)*	(0.22)	(0.50)	(0.15)
Social capital							-1.802	0.253		
							(1.22)	(0.32)		
Human capital									0.211	0.024
									(0.77)	(0.07)
F			2.289**			1.085		0.994		1.603
Anderson LR	9.826***	5.750*		9.388***	3.446		3.245		1.281	
Hansen J		2.478	75.080		0.058	36.068	0.058	36.516	0.146	58.775
AR(2)			-1.636			-1.650*		-1.572		-1.653*
Estimator	IV-1	IV-2	S-GMM	IV-1	IV-2	S-GMM	IV-2	S-GMM	IV-2	S-GMM
Instruments	2	3	82.000	3	4	97	4	97	5	124
N	42	75	349	37	69	202	40	202	33	341

* Growth rates calculated from GDP data in real 2000 U.S. dollars. Sampling frame selected to maximize sample size, and is hence unbalanced. Data periodicity five-year averages for 1999–2003 (cross-section) and 1968–2008 (panel). All variables are in log form. Heteroskedasticity and autocorrelation-robust standard errors are reported in parentheses. A lagged dependent variable (GMM only) and a constant term (all specifications) were included in the regressions, but not reported. * indicates significance at 10 percent level, ** indicates significance at 5 percent level, and *** indicates significance at 1 percent level.

Table A.6 provides rankings of the top 15 economies by trade impact, and their corresponding levels of trade openness, for the period 1999–2003. It is clear that there is very little relationship between them; indeed, the correlation between the two series is -0.091 (and statistically insignificant at the conventional levels).

Table A.6: Top 15 countries in trade impact, 1999–2003 period average*

Country	**Trade impact**	**TI Rank**	**Trade openness**	**TO Rank**
United States	0.191	1	0.189	153
Germany	0.081	2	0.558	79
China	0.059	3	0.385	123
Japan	0.056	4	0.184	155
United Kingdom	0.056	5	0.415	118
France	0.049	6	0.435	112
Italy	0.039	7	0.427	116
Canada	0.036	8	0.672	55
Netherlands	0.032	9	1.027	19
Belgium	0.030	10	1.591	4
Spain	0.027	11	0.444	110
Mexico	0.026	12	0.524	90
South Korea	0.024	13	0.572	76
Taiwan, China	0.019	14	0.787	44
Switzerland	0.014	15	0.650	62

* Authors' calculations, using data from the Direction of Trade Statistics and World Development Indicators. Trade impact defined as the import share of global exports, and trade openness defined as the sum of imports and exports as a share of GDP.